DMAIC: A Proposed Method to Improve the Cleaning and Disinfection Process in Hospitals

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Abstract. The hospital environment influences the chain of transmission of pathogenic microorganisms linked to the incidence of infections, making cleaning and disinfection (L&D) management measures necessary in order to contribute to patient safety. This study aimed to propose the viability of using the Lean Six Sigma approach in the management and improvement of the hospital terminal hygiene process. **Method:** Exploratory descriptive research, through a theoretical survey of tools used in the Lean Six Sigma approach. The DMAIC method, was used as a guide for this project hypothesis of management of the process of terminal hygienization of beds of a University Hospital in the city of Rio de Janeiro. **Results:** In the definition and organization phase of the project, the terminal sanitization process can be mapped through the VSM diagram and by an employee interview instrument during GEMBA. L&D quality assessment tools like fluorescent markers, ATP test and microbiological cultures can serve as pre and post indicators for possible improvement interventions. Tools such as: Current Reality Tree; GUT matrix; Prioritization matrix and 5W2H plan have proven to be good choices for the analysis and improvement phases. Finally, audits, visual and participative management, indicator reports for maintenance of actions can be done. **Conclusion:** The application of the DMAIC method of the Lean Six Sigma approach in hospital cleaning processes proved to be objective and feasible according to the proposed method, presenting itself as an alternative basis for future projects in the area.

Keywords: Disinfection · Cleaning hospital service · Action Research · Health Care Associated Infection

1 Introduction

Healthcare-Related Infections (HAIs) are one of the leading causes of death in the world, killing more people in the U.S. when compared to AIDS, breast cancer and traffic accidents [2]. Patients with weakened immune systems, such as patients with hematological diseases undergoing chemotherapy, and who have

undergone a greater number of invasive procedures, are the most susceptible to SAIs [3].

A study by the World Health Organization - WHO showed an increase in the prevalence of these infections in patients hospitalized in Intensive Care Units - ICU, surgical and orthopedic wards1. In developed countries, 5 to 10% of patients admitted to the ICU acquire an infection. In Brazil, of all recorded admissions, the infection rate is around 14% [2, 19]. Another important data is that after adherence to bundled practice protocols, which is an evidence-based structured way of improving processes and patient care, a reduction of up to 70% of bloodstream infections was obtained [5].

There is evidence that the environment has a strong influence on the chain of transmission of microorganisms linked to the incidence of infections. Contaminated surfaces can serve as reservoirs for microorganisms, especially those resistant to antimicrobial agents, making the hospital environment, even indirectly, a substantial risk to the patient [1, 10, 14].

Hospital hygienization is achieved through cleaning and disinfection procedures. If in cleaning the focus is on the removal of organic matter, disinfection aims to remove or eliminate microorganisms in their vegetative form, not necessarily in sporulated forms, through chemical agents applied to inanimate surfaces, such as equipment and fixed surfaces, which were previously cleaned [1]. Surfaces close to the patient are touched more by the hands, and therefore, should be cleaned and disinfected more frequently. Evaluating and ensuring adequate sanitation of these surfaces has a positive impact on the treatment and recovery of patients' health [1, 3].

On the other hand, terminal cleaning is defined as the process of cleaning and/or disinfecting all areas of the health care service to reduce dirt, microbial population, and the possibility of environmental contamination. However, it is carried out periodically, on a scheduled basis, and includes floors, walls, ceilings, and all furniture. It is carried out after the patient's discharge, transfer, or death [1].

Studies show that when a patient is admitted to a bed where there was previously a patient colonized by multi-drugs resistant microorganisms, there is a higher incidence of colonization by this same pathogen. Another reports that contaminated surfaces increased by more than 100% the risk of colonization of susceptible patients who occupied the same room as previously colonized patients [7].

It is common to find inadequate processes in terms of quality management of sanitation in the hospital environment mainly due to flaws in technique, routine, lack of monitoring, and qualified human resources, among others. Due to the importance of the issue, regulatory agencies recommend the use of monitoring methods of hospital cleaning/disinfection as an essential part of the institutional hospital infection control program [1].

The four main resources used for this purpose are: visual inspection, fluorescent markers, ATP testing, and microbiological cultures [6].

Visual inspection is the most commonly used method and sometimes the only one. Despite its low cost, it depends on a personal assessment and can be quite subjective. Studies have shown that surfaces were considered approved by visual inspection even before they were cleaned and disinfected, and it is not considered a good marker by itself [6].

The use of fluorescent products gives immediate feedback, is fast and easy to apply, but is laborious, because it must be marked without the staff noticing, and after cleaning, the places must be evaluated. Like visual inspection, it does not assess the microbial load [15].

The bioluminescence ATP test is a quick and objective method that provides a quantitative measurement. Its disadvantages include high cost, no identification of microorganisms, no cut-off point or standard, and the possibility of false-positive results [7].

The microbiological culture of the environment, considered the gold standard method, has high sensitivity and specificity and identifies the type of pathogen contaminating the area being evaluated. However, it is the least used and standardized method in institutions due to its high cost, necessary supplies, and delay in results, being used in cases of outbreaks and research [6].

Yearning for change and improvement, health services in general have sought new tools to manage and control their processes, identify problems and solve them effectively, such as Lean Six Sigma. The Six Sigma methodology is quantitative, structured, and focused on improving processes that already exist in the institution. It occurs with little or no investment and can be an excellent strategy for creating a culture of continuous improvement of results by increasing the quality of hospital hygiene processes [12].

The structured method often used in Six Sigma is the DMAIC (define-measure-analyze-improve-control) method, and statistical tools that assess opportunities for improvement [16, 17]. Lean Six Sigma has been contributing significantly to problem identification and resolution, process quality improvement, external (patients) and internal (healthcare professionals) customer satisfaction, and reduction of associated costs, operating expenses, and inventory [9].

Despite being highly recommended, using existing technologies and tools to understand and measure the sanitation process does not guarantee, by itself, a safe environment, free of pathogenic microorganisms. Considering that there are no indicators of quality in the cleaning of hospital surfaces in the study scenario of this research, the following question was defined: Is the application of Lean Six Sigma considered an effective strategy to improve the quality of processes related to hospital cleaning? Based on this premise, the study in question aimed to propose the feasibility of using the LEAN Six Sigma approach as a way of managing and improving the process hospital terminal sanitation.

2 Methods

This is an exploratory study, performed by a professional specialist in hospital infection control.

In order to facilitate the theory development through practical application, an Action Research methodology will be used. DMAIC method and action research study conducted in a hospital is a classic example of how LSS can bring bottom-line impact to an organization, alongside contributing to the process improvement mind-set in employees [8].

In a first moment, articles and case studies with a Lean Six Sigma approach were surveyed in literature, as well as frequently used quality tools. In parallel, the standard operating process for terminal hygiene of the beds was reviewed. A new literature search was performed, this time focusing on the existing cleaning and disinfection quality monitoring tools, to serve as indicators for this Lean Six Sigma project proposal. Finally, we tested the use of the DMAIC method as a guide to know the current state of the process, identify opportunities for improvement and effective interventions for the same.

The choice of this method was based on its structure, which allows the achievement of goals through accurate knowledge of the entire problem, avoiding hasty conclusions, and the spending of financial and human resources on ineffective actions [16]. In other words, this management method follows the effectiveness of process management through the diagnosis of an undesirable situation and the consequent search for solutions. Its main objective is to control and improve processes, services, and products in a continuous manner, with a beginning, middle, and end, bringing as an important aspect not only the solution of problems but also the issue of sustaining the proposed work [4].

Therefore, DMAIC depends on metrics (indicators) and reliable data to verify the quality of a process in statistical terms, evaluating what is being done, produced, if it is according to what is recommended or within the expected specifications [17].

3 Result

3.1 Definition phase

To clearly define the scope of the project, it is necessary to assess the history of the problem and agree on the points of the project through a contract that should answer the following questions: What is the problem you want to solve? What is the goal to be achieved and what gains does it correspond to? Which process/stage is related to the problem in question?

It is worth remembering that this project covers the improvement of processes related to cleaning the hospital environment, which in turn covers the control of health care-related infections and patient safety, and is therefore consistent with the strategic planning of the study institution. This is an important aspect to start any Lean Six Sigma project. Other characteristics of a good project are that there must be a reliable database to measure the current state and the results after the intervention. In this case we will create these reliable and measurable indicators, and the solutions at the moment to solve the problem are not known to the institution.

In the definition phase the reasoning map compiles and documents project information in an objective and precise manner, creating a mental model and facilitating the conduction of the project. In this map it is already possible to foresee the possible tools to be used, to register the evolution of the actions in real time, and to promote the understanding of the project by people outside the team because it demonstrates how and why the data was collected. It allows contribution through ideas, shows which questions still need to be answered and which have already been completed [17].

The Project Agreement is the final deliverable of the definition phase containing a lot of important information, containing the LSS project planning, theme, the involved team, global goals from the problem, history, indicators, involved process.

3.2 Measurement stage

In this stage, the problem defined in the previous stage must be analyzed in greater depth, with the help of statistics and process mapping. This moment is extremely important, because by knowing the problem in depth it will be possible to identify its possible causes.

Value Stream Mapping (VSM) is a structured diagram that will document all the processes involved from the beginning to the end of a hospital's terminal sanitation. The VSM allows you to know the process and record the duration of each step, as well as the conformities and non-conformities according to the Standard Operating Protocol - SOP guidance [20].

The data is collected where the process occurs (checklist) being essential in order to discover bottlenecks and potential improvements. This tool can capture the process "how it is" and not as "we suppose it to be" (Figure 1).

The evaluation of the quality of room cleaning and disinfection can occur by using one or all of these three techniques: fluorescent markers, ATP test, and room culture. The choice of the suitable technique will vary according to either the human or the financial resources of each institution. It is worth mentioning that the researcher/evaluator does not interfere with the observations and tests in this initial phase.

Another way to identify problems and possible solutions is through observation and questions about the process to those who perform it, that is, to go to the "shop floor". This term, also known as "Gemba", is a Japanese term meaning " the place where things happen in manufacturing. ". In the context of LEAN it is the workplace where the process takes place [17]. Gemba can occur through an oral interview script, composed of open-ended questions.

3.3 Analysis Stage

This stage aims to seek proof of the causes of the problem identified previously, through facts, such as records, graphs and data. The main job is to identify the root cause(s) of the problem, so that the next stage can intervene.

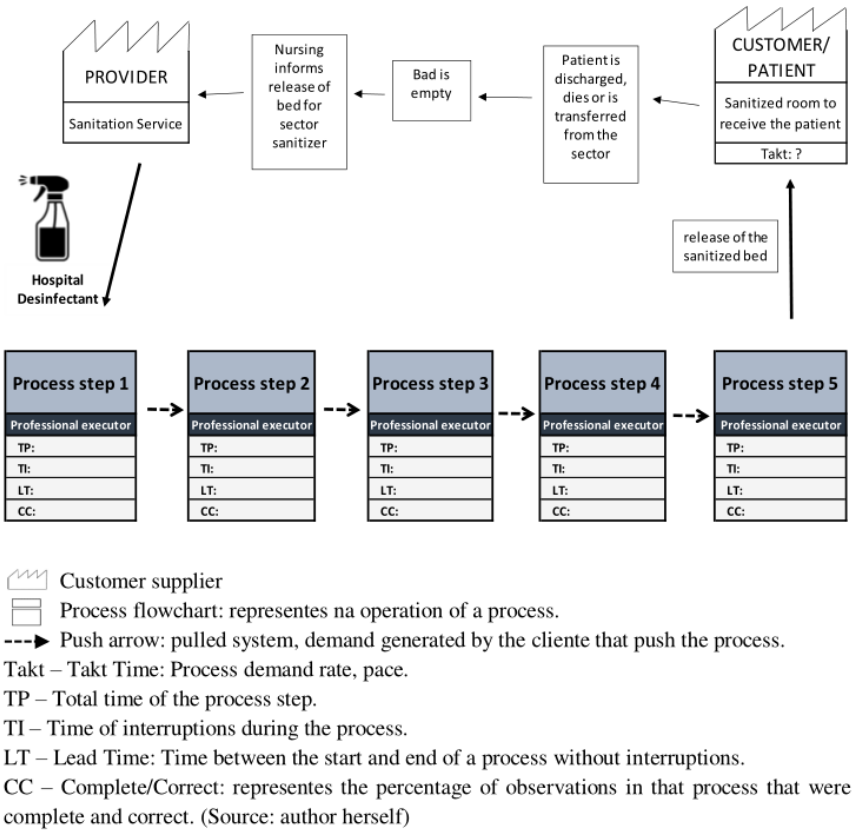

Fig. 1. VSM model for the terminal cleaning process according to institutional recommendation.

The Current Reality Tree (ARA) has its origin in the Theory of Constraints, which brings the concept that all the elements that constitute a system have an interdependent relationship among themselves, and that every system has a single cause for several effects that affect it. ARA will be used to identify a common causer that is generating unwanted effects, and this cause and effect relationship is created from the formation: "If... Then". That is, "If the hypothesis is true, then such an effect will occur " [13].

The GUT Matrix at this point will be used to prioritize the treatment of the problems found considering their severity, urgency and tendency. The severity (G) refers to the impact of a certain problem on people, things, processes, as well as the consequences of the permanence of this problem if it is not solved. Urgency (U) refers to the time needed to solve the problem, and trend (T) is the

ability of a problem to grow over time, whether it tends to increase or decrease for example [11].

In the DMAIC analysis phase, the relationship between the prioritized causes (variable Xs) in relation to the result of interest (variable Y) must be verified through statistical analysis.

If the goal is to correlate two variables (x and y) to find out if changing the X variable affects the behavior of the Y variable, for continuous data statistical tools can be used: Correlation; Scatter Diagram; and Simple Linear Regression. For discrete data I will use the Chi-square test.

If the focus is to demonstrate that the stratification of variable Y generates different results, i.e., that the stratification factors represent causation, then for continuous and discrete data you can use Hypothesis Tests, Test of Equality of Variance, ANOVA and Multi-Variance Plots [18].

3.4 Improvement stage

In this phase the objective is to propose, test and execute solutions for the problems found. It is common to have many improvement ideas that can result in a voluminous action plan that is difficult to execute on time.

The Prioritization Matrix or Effort and Impact Matrix is a tool that uses scores to correlate the proposed solutions to the prioritization criteria. The most common criteria are: low cost, ease, speed, impact on the Root Cause, and low or high probability of causing undesired effects. A weight is defined for each criterion (e.g. 5 to 10 points) and a scoring legend is used for the relationship between each criterion and solution (e.g. 0 - no correlation; 1 - weak correlation; 3 - moderate correlation; 5 - strong correlation). Multiplying the value generated by the weight of the criterion and adding the values in the row gives the final result, that is, the improvement solutions that should be prioritized in the action plan [20].

To unfold the elected ideas into more tangible information, the 5W2H Action Plan will be used. This diagram-shaped model clearly and concisely lists what will be done (What), when it will be done (When), who will do it (Who), where it will be done (Where), why it will be done (Why), how it will be done (How), and the financial impact of the action (How Much) [11, 20].

In the execution of the improvement plan the results are generated. The level of results depends on the quality of the actions and the level of execution of the proposed action plan. In this stage, the objectives are: to guarantee the execution of the actions outlined in the planning stage; to disclose the actions to everyone in order to obtain an alignment among the involved areas and to promote training if necessary to guarantee the actions.

3.5 Control stage (Control)

After the implementation of the improvement actions it is necessary to evaluate and monitor the achieved results to ensure their sustainability. Some practices

used in this stage are Audits; View Management Board; Reports sent to leaders with project indicators; and Participative Management with monthly strategy alignment meetings [4, 16, 17].

4 Conclusion

The application of the DMAIC method of the Lean Six Sigma approach in hospital sanitation processes proved to be objective and feasible according to the proposed step-by-step instructions, presenting itself as an excellent alternative basis for future improvement projects in the area. Once all the steps of the method were structured, it is possible to reproduce it for other health institutions with small adjustments according to the SOP guidance of each location and physical structure.

Finally, the paper has suggested that Action Research is a suitable research design for Lean Six Sigma/DMAIC projects allowing a collaborative approach to knowledge enhancement based on the researcher and research becoming equal in the pursuit of knowledge.

Actions to improve processes related to the cleaning of hospital surfaces are capable of promoting a safer environment for patients, companions, and healthcare professionals. Through the DMAIC method proposed in Lean Six Sigma projects it will be possible to identify possible losses such as: rework, unnecessary movement, inadequate spending of material, incorrect sanitizing technique, lack of standardization, among others.

It is also possible to obtain potential gains through the creation of performance indicators, standardization and optimization of the work process, creation of active listening and valorization of the hygiene professionals.

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